

## Criteria for Evaluating the Horizontal Deformation in the Upper Berm and Crest of the Reservoir Dam as a Result of Hydrostatic Pressure and Filtration

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The magnitude of the horizontal pressure generated in the dam body under the influence of the hydrostatic pressure force from the high bef on the reservoir dam depends on the angle of inclination of the soil in the dam body relative to the horizontal plane, its physical and mechanical properties, the frictional forces generated in the areas in contact with the anti-filtration screen and the core, and the structures protecting the dam against horizontal displacement and depends on gravity factors.

In some cases, the effect of water pressure in the pores on the body of the dam can be determined through the water level in the pezometers in the corresponding stvors.

We studied the horizontal deformation of the grunt structure in the upper befi berms of the reservoir dam under the influence of hydrostatic pressure force. To do this, we use the simple scheme presented in Figure 1. We define the horizontal organizer of the hydrostatic pressure force as  $P_x$ .

In the quiescent state of the dam grunt,  $\Delta_x = 0$ , and let us express the quiescent hydrostatic pressure force as:

$$P_0(z) \approx P_x(z, \Delta_x) \Big|_{\Delta_x=0} = E_u \cdot \gamma \cdot z \cdot S \cdot \cos \varphi \quad (1)$$

here:  $E_u$  – Euler criterion. The Euler criterion characterizes the effect of hydrostatic pressure changes on the movement of fluid particles.  $\kappa$  is the filtration coefficient,  $\rho$  - is the dam grunt density,  $P$ - is the hydrostatic pressure,  $\gamma$  - is the specific gravity of water,  $z$  - the distance from the water level at the upper level to the looking particle of the dam floor,  $S$  - at a normal steamed level, the holed surface of the upper otkos has a surface area of,  $\cos \varphi$  – the displacement angle of the brand in the range of geodesic measurement cycles,  $\Delta_x$  - horizontal displacement of the mark on the dam along the  $x$ -axis [mm]

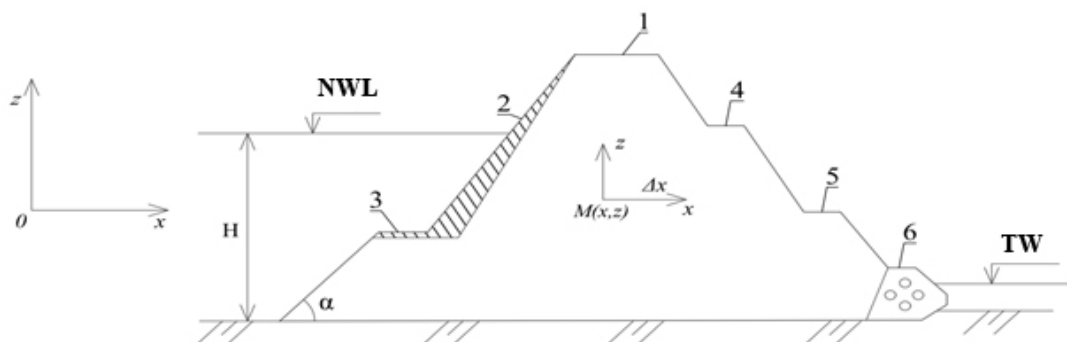


Figure 1. Transverse profile of the ground dam

here: 1 – the top of the dam; 2 – high slope; 3,4,5 – berms of upper and lower levels, respectively; 6 – drainage banquette; NWL - normal water level; TW – tailwater level;  $M(x,z)$  – ground particle;  $\Delta_x$  – horizontal displacement of the ground;

As the water level in the reservoir rises above the normal wetted level, the effect of the hydrostatic pressure force on the ground of the dam body increases sharply, and the hydrostatic pressure force begins to have an active effect, we denote this force by  $P_f$ . If the water level at the upper level approaches the dead water level, the hydrostatic pressure force decreases and has a passive effect.

To determine the minimum and maximum values of the hydrostatic pressure force, we write the following expressions:

$$P_{\max}(z) = (\lambda_{\max}\gamma z - E_u \cdot c) \cdot S \cdot \cos \varphi \quad (2)$$

$$P_{\min}(z) = (\lambda_{\min}\gamma z - E_u \cdot c) \cdot S \cdot \cos \varphi \quad (3)$$

here:  $\lambda_{\max}$  - is the hydraulic resistance coefficient of the filtration flow in the dam body at the maximum value of the hydrostatic pressure force,  $\lambda_{\min}$  – coefficient of hydraulic resistance that occurs at the minimum value of the hydrostatic pressure force in the filtration flow in the dam body,  $c$  – the quantity characterizing the relative displacement resistance of the dam soil [Pa].

The values of the hydrostatic pressure force at the maximum and minimum water levels in the reservoir are the limit values of the hydrostatic pressure force and vary in the following range:

$$P_{\min}(z) \leq P_x(z, \Delta_x) \Big|_{\Delta_x=0} \leq P_{\max} \quad (4)$$

Due to the change of the water level in the reservoir, the effect of the hydrostatic pressure force on the slope of the upper level of the dam, including the particles of the dam soil, is complex, and the change of the hydrostatic pressure force on the dam body can be expressed by the following criteria:

$$P_x(\Delta_x) = \begin{cases} P_{\min}, & \Delta_{\min} \leq \Delta_x \\ f(\Delta_x), & \Delta_{\min} < \Delta_x < \Delta_{\max} \\ P_{\max}, & \Delta_x \leq \Delta_{\max} \end{cases} \quad (5)$$

After appropriate simplifications,  $f(\Delta_x)$  can be replaced by a linear function:

$$f(\Delta_x) = P_0 - \kappa_{rp} \cdot \Delta_x \cdot S \cos \varphi \quad (6)$$

here:  $\kappa_{rp}$  – density coefficient of the dam body soil  $\left[\frac{H}{M^3}\right]$ ,  $\Delta_x$  – horizontal displacement of the stamp on the dam along the x - axis [mm].

We describe the effect of the hydrostatic pressure force on the top of the dam at different water levels in the reservoir in the form of a graph presented in Fig. 2. We describe the effect of the hydrostatic pressure force on the top of the dam at different water levels in the reservoir in the form of a graph presented in Fig. 2.

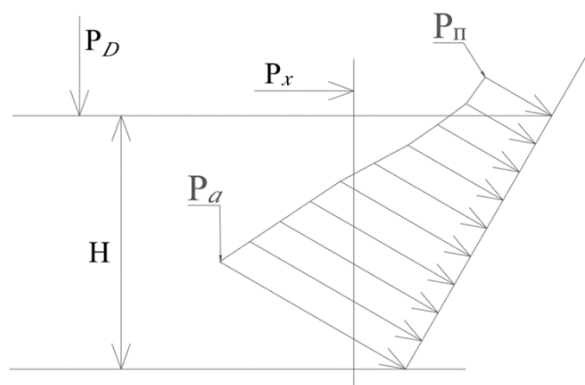


Figure 2. Graph of hydrostatic pressure force limits

Now we build the function  $P_x(z, \Delta_x)$  in the form of a piecewise function.

According to the hydrostatic pressure epic in Figure 2, the piecewise function takes the view on the sheep:

$$P_x(z, \Delta_x) = \begin{cases} P_{\min}(z), & \Delta_x \leq \Delta_1 \\ P_0(z) - \kappa_{rp} \cdot \Delta_x \cdot S \cdot \cos \varphi, & \Delta_1 < \Delta_x < \Delta_3 \\ P_{\max}(z), & \Delta_3 \leq \Delta_x \end{cases} \quad (7)$$

or

$$P_x(z, \Delta_x) = \begin{cases} (\lambda_{\min} \cdot \gamma \cdot \Delta_x - E_u \cdot c) \cdot S & \Delta_x \leq \Delta_1 \\ E_u \cdot \gamma \cdot \Delta_x \cdot S \cdot \cos \varphi & \Delta_1 < \Delta_x < \Delta_2 \\ (\lambda_M \cdot \gamma \cdot \Delta_x - E_u \cdot c) \cdot S \cdot \cos \varphi & \Delta_2 \leq \Delta_x \end{cases} \quad (8)$$

Under conditions  $\Delta_x \leq 1$  and  $\Delta_1 < \Delta_x < \Delta_2$ , a process of near-deformation by the reservoir dam does not occur during the long-term exploitation.

However, under the condition  $\Delta_2 \leq \Delta_x$  at the maximum values of the hydrostatic pressure force, horizontal displacement of particles by the dam occurs.

From the course of hydraulics it is known that the hydrostatic pressure force acting on a flat surface at an angle is expressed through the following formula:

$$P_0(z) = (P_0 + \gamma \cdot h_c) \cdot S \quad (9)$$

here:  $P_0 = P_A$  – is the atmospheric pressure,  $\gamma$  - is the specific gravity of water,  $h_c$  is the depth from the water level at the top level to the center of the slope surface at the top level of the dam,  $S$  - is the surface surface at the bottom of the slope.

Based on Equation 3 (third) of Condition (1), (9) and (8), we get the following expression:

$$(P_0 + \gamma \cdot h_c) \cdot S = (\lambda_M \cdot \gamma \cdot \Delta_x - E_u \cdot c) \cdot S \cdot \cos \varphi \quad (10)$$

(10) from the equation we get the following expression:

$$\cos \varphi = \frac{P_0 + \gamma \cdot h_c}{\lambda_M \cdot \gamma \cdot \Delta_x - E_u \cdot c}$$

or

$$\varphi = \arccos \left( \frac{P_0 + \gamma \cdot h_c}{\lambda_M \cdot \gamma \cdot \Delta_x - E_u \cdot c} \right) \quad (11)$$

As a result, we had the expression for determining the angle between stvors during the cycle of Geodetic measurements.

(11) numerical solutions of the equation, the parameters of the Okhdarya reservoir dam, which was considered the object of research, were used. In 2022, amalga Oshirilgan geodesic Ulchov Ishlar began construction of the takkosland building. It accounted for 4%.

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